Description

Method for simulating a movement by means of an
acoustic reproduction device, and sound reproduction
5 arrangement therefor

The invention relates to a method for simulating a
movement in a predetermined direction relative to a
reference point in the surroundings of an acoustic
10 reproduction device, and to a sound reproduction
arrangement for carrying out such a method.

A moving performance from sound sources is known in
principle in the prior art. In this case, a person in
15 the surroundings of the acoustic reproduction device
has movement through space simulated by virtue of a
sound source produced by the acoustic reproduction
device moving relative to the person in a predetermined
direction of movement.
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A simple example in this context is the movement of a
sound source from a first loudspeaker to a second
loudspeaker, which is at a distance from the first
loudspeaker, by means of an acoustic reproduction
25 device.

In the prior art, the person skilled in the art of the
technical field which is relevant in this context is
also aware of the implementation of "virtual sound
30 sources", however. A virtual sound source is
implemented by means of suitable superimposition of
sound signals, so that a person hearing these signals
is given the impression that the sound signals heard
came from a particular point in space in his
35 surroundings. In this context, reference is made to the
specialist article "An Interactive Virtual-Environment
Generator

for Psychoacoustic Research, I: Architecture and Implementation" by J. Blauert et al. in ACUSTICA/Acta Acustica" 86, 2000, pp. 94-102. This gives a detailed description of the implementation of virtual sound sources. Mention can also be made of the specialist article "Binaural Room Scanning - A new Tool for Acoustic and Psychoacoustic Research" by P. Mackensen et al., which appeared in the DAGA 1999 conference report (annual conference of the German acoustics society), which mentions the movement of a virtual sound source.

However, a method for simulating a movement by means of a virtual sound source has the drawback that this sound source needs to move on a circular path, for example, in order to indicate a movement in a particular direction continuously. If the sound source is moving in a straight line, the sound source will become increasingly distant from the person, which means that at a particular time it is no longer possible to indicate the movement to the person.

Against this background, the invention is based on the object of using an acoustic reproduction device to simulate a movement in a predetermined direction, with a generated sound source needing both to simulate a movement and to remain essentially fixed in space.

This object is achieved by a method for simulating a movement in a predetermined direction relative to a reference point in the surroundings of an acoustic reproduction device, having the following steps:
a)   the acoustic reproduction device is provided in order to produce at least two virtual sound sources,
b)   the acoustic reproduction device is controlled using a control unit which is designed for the repeated movement of the at least two virtual sound sources in succession from a predetermined starting point to a

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predetermined ending point, and from there abruptly back to the starting

point, where a direction of movement for the at least
two virtual sound sources coincides with the direction
of the movement which is to be simulated.

5   The effect of the proposed method is that a person who
is at the reference point perceives the at least two
virtual sound sources as a single sound source which is
essentially at a fixed location but simulates movement
from the starting point to the ending point.
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Preferably, the control in step b) takes place such
that a movement by the at least two virtual sound
sources is effected essentially at right angles to a
connecting line between the reference point and a point
15   in the center between the starting point and the ending
point of the movement by the at least two virtual sound
sources. In this way, it is possible to ensure
particularly clear perception of the movement when the
aim is to indicate to the person a particular direction
20   of movement by means of the acoustic reproduction
device.

If the method is used to indicate to a person the
directions "left" or "right" in relation to the
25   person's head, for example, then the method can be
carried out in the described manner, with the at least
two virtual sound sources in this case being moved
either from right to left and abruptly back again or
from left to right and abruptly back again by means of
30   the control unit. In this context, the mid-point will
be situated between the starting point and the ending
point of the movement by the at least two virtual sound
sources approximately in the center of the person's
field of vision.
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Alternatively, however, it is also possible to use the
method to simulate movements which are at an angle to
the connecting line between the reference point and the

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mid-point between the starting point and the ending
point. If the method is used

in combination with a navigation system in a motor vehicle, for example, the path between the starting point and the ending point may correspond to a direction which is prescribed by the navigation system. Depending on the respective current whereabouts of the motor vehicle, the path of movement for the at least two virtual sound sources can be adapted such that the direction of travel which is to be selected for the motor vehicle is always indicated audibly.

However, indicating the directions "right" and "left" will probably be the main instance of application of the method in connection with location-related services, such as a navigation system.

In one preferred embodiment, the control in step b) takes place such that for each virtual sound source there is an increase in the sound intensity from the starting point to the mid-point and a decrease in the sound intensity from the mid-point to the ending point. This measure contributes to giving the person who perceives the acoustic reproduction device the impression that there is only a single, essentially fixed-location sound source. In particular, the sound intensity can increase at a constant rate up to the mid-point and can decrease at the same rate from the mid-point to the ending point.

To simulate a uniform movement, it is preferable for a speed of movement for the at least two virtual sound sources to be constant in step b).

To improve the perception properties of the acoustic reproduction device, there should preferably be at least four virtual sound sources used which are controlled in the manner explained with reference to the aforementioned at least two virtual sound sources.

The aforementioned object is likewise achieved by a sound reproduction arrangement having an acoustic reproduction apparatus for simulating a movement in a predetermined direction relative to a reference point
5   in the surroundings of an acoustic reproduction device and for producing at least two virtual sound sources and having a control unit which is designed for the repeated movement of the at least two virtual sound sources in succession from a predetermined starting
10   point to a predetermined ending point, and from there abruptly back to the starting point, where a direction of movement for the at least two virtual sound sources coincides with the direction of the movement which is to be simulated.
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The operation of such a sound reproduction arrangement has already been explained above with reference to the proposed method. Preferred embodiments of the sound reproduction arrangement can be found in Claims 7 to 9.
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An exemplary embodiment of the invention is explained in even more detail below with reference to the single drawing. The single drawing shows a time sequence for arrangements comprising a plurality of virtual sound
25   sources in relation to a person in the surroundings of the sound sources to illustrate a method for simulating a movement for the person.

With regard to the figure, it should be pointed out
30   that the distance shown between virtual sound sources VS A, VS B, VS C and VS D, that is to say four virtual sound sources, and a person, who is represented by an ellipse as a stylized view from above his head, need not be comparable with actual distances. In certain
35   instances of application, the distance will be very short, as suggested by the drawing, but it is also possible for

the virtual sound sources VS A, VS B VS C and VS D to
be at a considerable distance from the person P.

In the exemplary embodiment shown, the four virtual
5   sound sources VS A, VS B, VS C and VS D are shown both
at a time T = 0 s and at further times, where T = 2 s,
T = 4 s and T = 6 s. This illustrates how the relative
movement of the individual virtual sound sources VS A,
VS B, VS C and VS D relative to the person is executed
10   as a function of time.

At the time T = 0 s, the virtual sound sources VS A, VS
B, VS C and VS D are in an initial formation, where
they are situated on a common line, in the present
15   exemplary embodiment a straight line. At the time T =
2 s, all of the virtual sound sources have moved one
interval to the left at the same speed, this movement
continuing up to a time T = 4 s.

20   At the time T = 6 s, the leading virtual sound source
VS A has been abruptly moved behind the virtual sound
source VS D, which means that the virtual sound source
VS B is now the leading one and the virtual sound
source VS A is now the lagging sound source.
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Overall, a movement from right to left in the drawing
is thus obtained for all of the virtual sound sources
VS A, VS B, VS C and VS D. As soon as the virtual sound
source VS B, which is initially arranged behind the
30   virtual sound source VS A, has reached the original
position CT = 0 s) of the virtual sound source VS A in
the course of time, the virtual sound source VS A is
abruptly moved to the end of the row of virtual sound
sources VS A, VS B, VS C, VS D.

The path to be covered by each virtual sound source VS
A, VS B, VS C and VS D in order to simulate a movement
in the direction of an arrow B in the figure for the
person P is identical. This path is defined by a
starting point and an ending point. The starting point
is defined as that point in space to which each of the
virtual sound sources VS A, VS B, VS C, VS D is
abruptly returned when it has reached the ending point
on the path. When one of the virtual sound sources VS
A, VS B, VS C and VS D is abruptly returned to the
starting point SP, its sound intensity is preferably 0,
which means that no influence is exerted on the
acoustic perception by the person P as a result of
returning the virtual sound sources VS A, VS B, VS C,
VS D. In the case of impaired embodiments, the starting
point SP and the ending point EP for the path which is
to be covered may also vary.

A mid-point MP on the path covered by the virtual sound
sources VS A, VS B, VS C and VS D is situated
approximately in the direction of a horizontal mid-axis
in the field of vision of the person P. The path
covered runs approximately at right angles to a
connecting line V between the mid-point on the path and
the person P, who defines a reference point.

The movement of the virtual sound sources VS A, VS B,
VS C and VS D is controlled by a control unit (not
shown) which is connected to an acoustic reproduction
device (not shown), which may be the headphones or a
loudspeaker arrangement, for example.

The acoustic reproduction device and the control unit
together form a sound reproduction arrangement which is
suitable for carrying out the method. The control unit
tracks the position of each of the virtual sound
sources VS A, VS B, VS C and VS D at a particular time.
Depending on the respective

position, the control unit determines the intensity of
the sound signal which is emitted by a virtual sound
source VS A, VS B, VS C and VS D of interest. From the
starting point SP on the right-hand side of the figure
5   the intensity increases up to the aforementioned mid-
point MP, after which it decreases down to the ending
point EP. The sound intensity increases and decreases
at the same constant rate. This practice has the
advantage that the person P perceives the sound source
10 arrangement, which is obtained from the four
successively arranged virtual sound sources VS A, VS B,
VS C and VS D, to be a single sound source which is at
a fixed location but which simulates a movement from
right to left. In particular, a virtual sound source
15 situated at the left-hand edge is moved abruptly when
its intensity has reached its minimum.

As the audio signal which is to be emitted by the
virtual sound sources VS A, VS B, VS C and VS D, it is
20 possible to use white noise (MLS signal), for example.
In principle, what matters is that the emitted audio
signals have a bandwidth which allows the sound signals
to be localized. Alternatively, the virtual sound
sources VS A, VS B, VS C and VS D may also be voice
25 signals or "auditory icons", which are naturally or
synthetically generated sound signals which have an
associated function and which are related to this
function by the person P as intuitively as possible. It
is important that all of the virtual sound sources VS
30 A, VS B, VS C and VS D emit the same audio signal,
possibly with changing intensity.

The text below describes a few exemplary embodiments of
the above-described method and of the associated sound
35 reproduction arrangement:

Application example 1

A person uses a navigation system which is installed in
a motor vehicle. When the navigation system uses a
voice output to suggest to the person that he turn off
to the left after 500 meters, for example, the voice
5   output is played back such that the four virtual sound
sources VS A, VS B, VS C and VS D move in the desired
direction, in the present case to the left.

Application example 2

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A person uses a location-related service using a mobile
telephone. In this case, he uses stereo headphones. The
location-related service indicates to the person that
he needs to move upward in order to find a department
15   which he is looking for within a shop. In this case,
the four virtual sound sources are moved by means of
the control unit such that a movement upward is
simulated. The audio signal played back in this case,
for example "Please move to the next floor up", then
20   forms the output signal from the virtual sound sources
VS A, VS B, VS C and VS D.

From the movement of the virtual sound sources VS A, VS
B, VS C and VS D, the person can intuitively tell that
25   he needs to go to the next floor up, for example using
an escalator.

Application example 3

30   A mobile telephone may be able to show user menus
virtually in space. In this case, the person using the
mobile telephone is visually given the impression that
more deeply nested menu entries are further away than
the top menu level. The person is thus able to obtain
35   an impression of what is hidden behind a menu item on
the top level, for example,

and can intuitively move through this virtual spatial
representation of menus.

To make navigation in a three-dimensional user menu of
this type intuitive, it is possible to use "three-
dimensional audio icons". Using these icons, it is
possible to convert a movement by the user into a
movement by the virtual sound sources VS A, VS B, VS C
and VS D and to render it audible to the user. In this
way, he can find his way around better in the three-
dimensional virtual spatial representation of the user
menus.

Application example 4

In the case of a game implemented on a mobile
telephone, the aim is to give a person the impression
that he is moving through a virtual world. In this
context, the person's speed of movement needs to
change. It is very difficult to clarify the change in
the speed of movement solely by means of a visual
impression which the person gets from the mobile
telephone's display panel, for example.

In this case, parallel performance of the method
described above allows the movement to be clarified by
virtue of sound effects which are played remaining at a
fixed location in space, on the one hand, while the
person perceives an apparent movement, on the other. In
this way, it is possible to "simulate" the impression
of different speeds of movement, for example, for the
person.

In this exemplary embodiment, the physical positions of
the starting point SP and of the ending point EP over
time are not fixed but rather time-dependent. This
means that the distance between the virtual sound

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sources VS A, VS B, VS C, VS D and the person is increased in the present case.

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In further application examples, it may also be appropriate for the path covered by the virtual sound sources VS A, VS B, VS C, VS D to be variable over time, but with each of the virtual sound sources VS A, VS B, VS C and VS D continuing to move along the path and to make the abrupt return movement, in particular.